MASTER IN SPACE SYSTEMS – TECHNIC UNIVERSITY OF MADRID

STK in the Master in Space Systems (MUSE)

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Briefing on the Master in Space Systems (MUSE)

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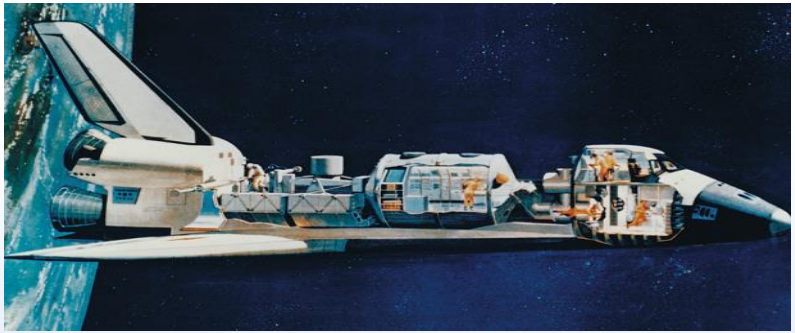
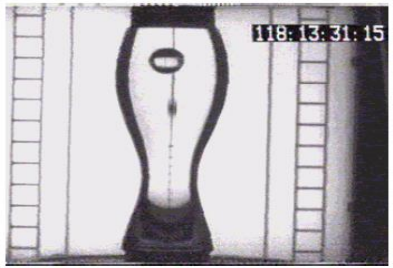
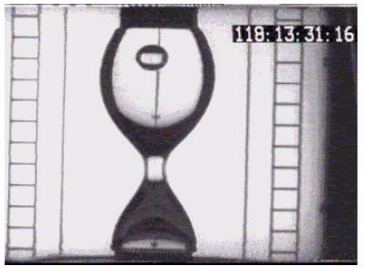
Research on Space at IDR/UPM

- Iniciated in the late 70s
  - Liquid bridges under microgravity
  - First Spanish experiment carried out in Space (1983)
- Handbook of Spacecraft Thermal Control (ESA)

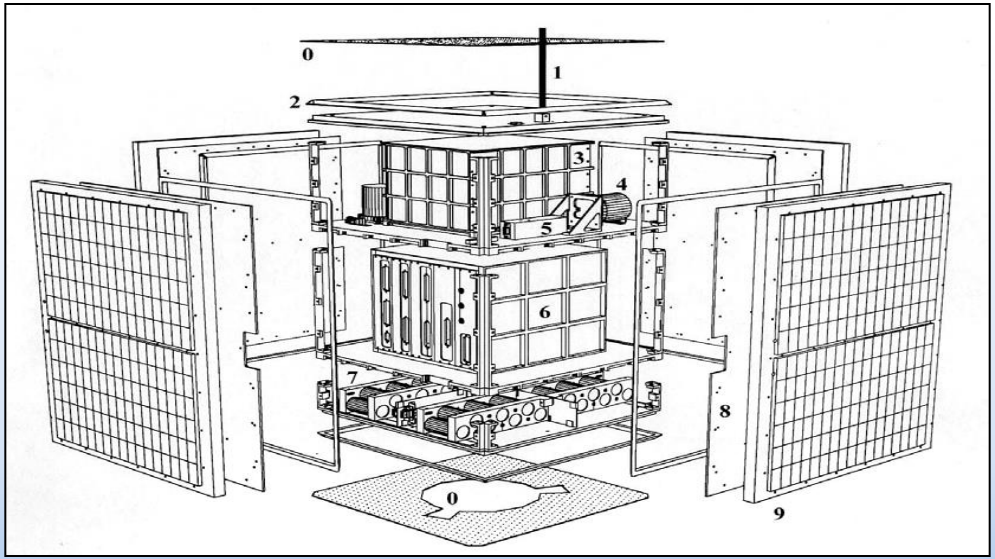






Research on Space at IDR/UPM

- **UPMSat-1 (1995)**



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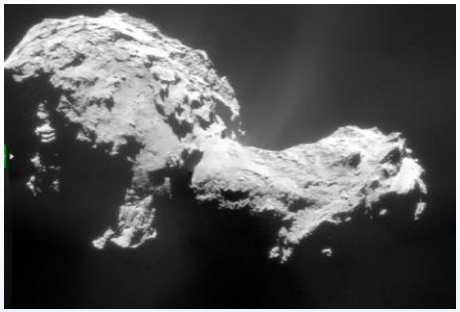
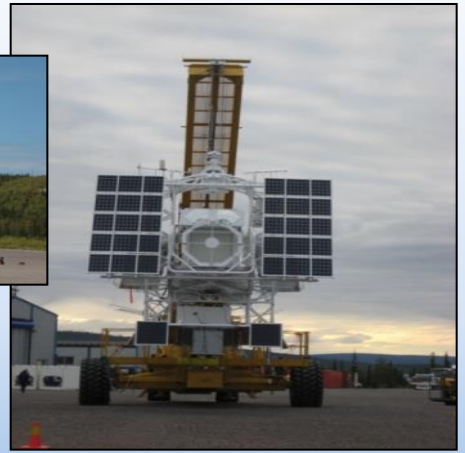
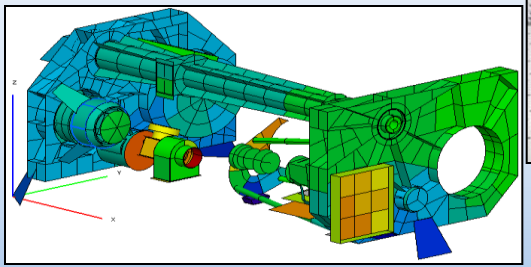
Research on Space at IDR/UPM

- Rosetta (2004)
- SUNRISE (2009)
- Solar Orbiter (2018)







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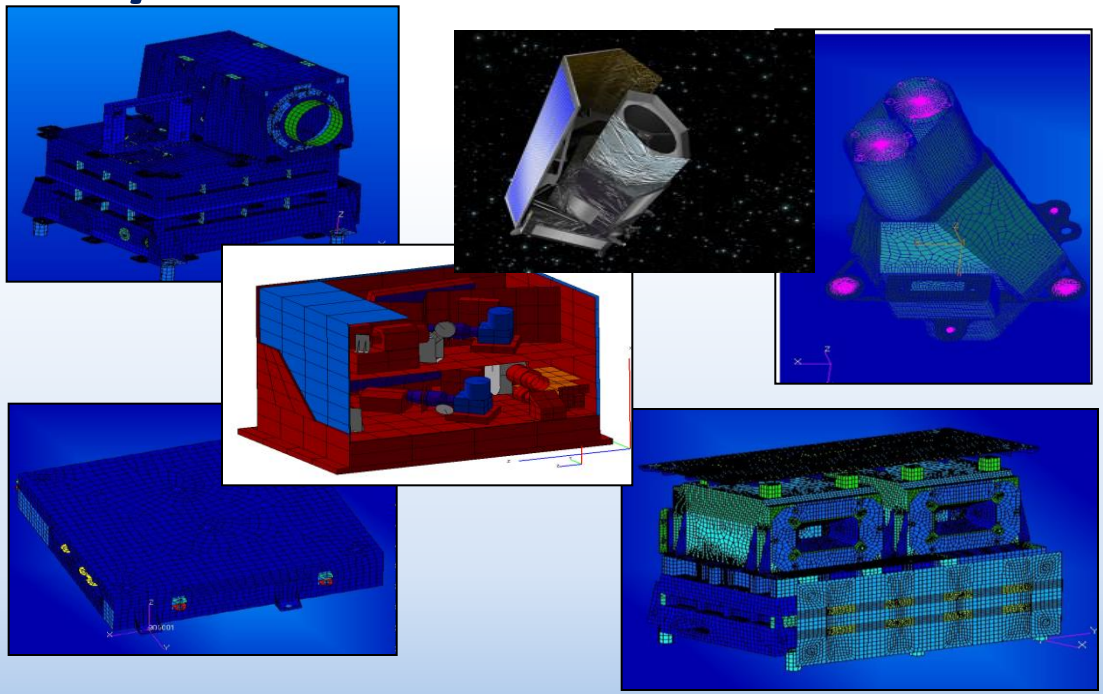
Research on Space at IDR/UPM

- EPD (2018)
  - EPT-HET
  - STEP
- RAMAN (2018)
  - iOH
- NOMAD (2016)
- EUCLID (2020)



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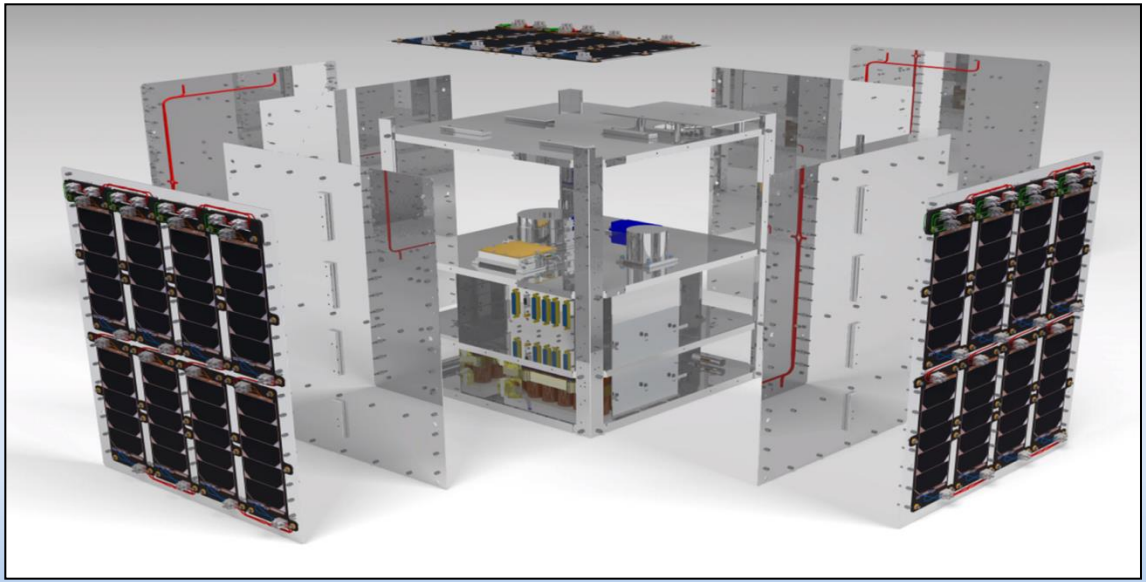
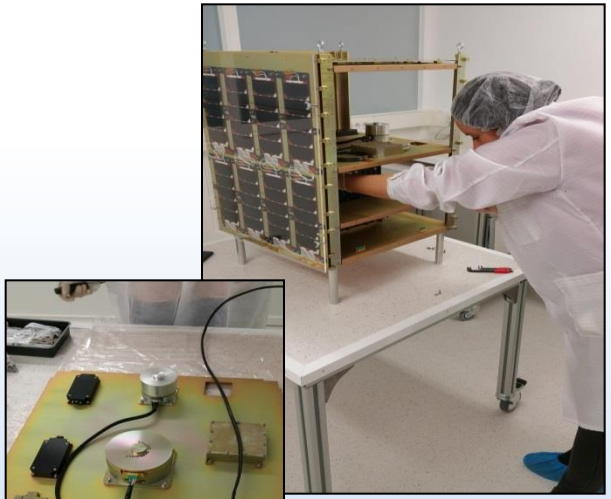
Research on Space at IDR/UPM

- **UPMSat-2 (2017)**





IDR/UPM Institute:

- Human resources
  - 47 researchers
  - Core of 7 professors
- Academic experience in space systems
  - Ph.D./Master final degree projects
- First official master's degree program by a research institute

MASTER IN SPACE SYSTEMS – TECHNIC UNIVERSITY OF MADRID

Current and future integration of STK software in the Master's Program

MASTER IN SPACE SYSTEMS – TECHNIC UNIVERSITY OF MADRID

Master's program:

- 2-year program
- 120 ECTS
  - Advanced Mathematics (12 ECTS)
  - Space Projects Definition (22.5 ECTS)
  - Systems Engineering (25.5 ECTS)
  - Spacecraft Subsystems (28.5 ECTS)
  - Case Studies and Master Thesis (31.5 ECTS)
- Project based learning

Master's program:

- **Space Projects Definition (22.5 ECTS)**
  - **Space environment and mission analysis**
  - **High speed aerodynamics and atmospheric reentry phenomena**
  - **Vibrations and aeroacoustics**
  - **Space materials**
  - **Graphic design for aerospace engineering**

Master's program:

- **Systems Engineering (25.5 ECTS)**
  - **Systems engineering and project management**
  - **Quality assurance**
  - **Space industry and institutions seminars**
  - **Production technologies**
  - **Space integration and testing**
  - **Spacecraft propulsion and launchers**

Master's program:

- **Spacecraft Subsystems (28.5 ECTS)**
  - **Orbital dynamics and attitude control**
  - **Heat transfer and thermal control**
  - **Power subsystems**
  - **Space structures**
  - **Communications**
  - **Data housekeeping**

Master's program:

- **Case Studies and Master Thesis (31.5 ECTS)**
  - **Testing the attitude positioning photodiodes of the UPMSat-2**
  - **Analysis, characterization and testing of the UPMSat-2 Reaction Wheel payload**
  - **Harness design for the UPMSat-2**
  - **Orbit analysis of the UNION/Lian-Hé satellite at the CDF**

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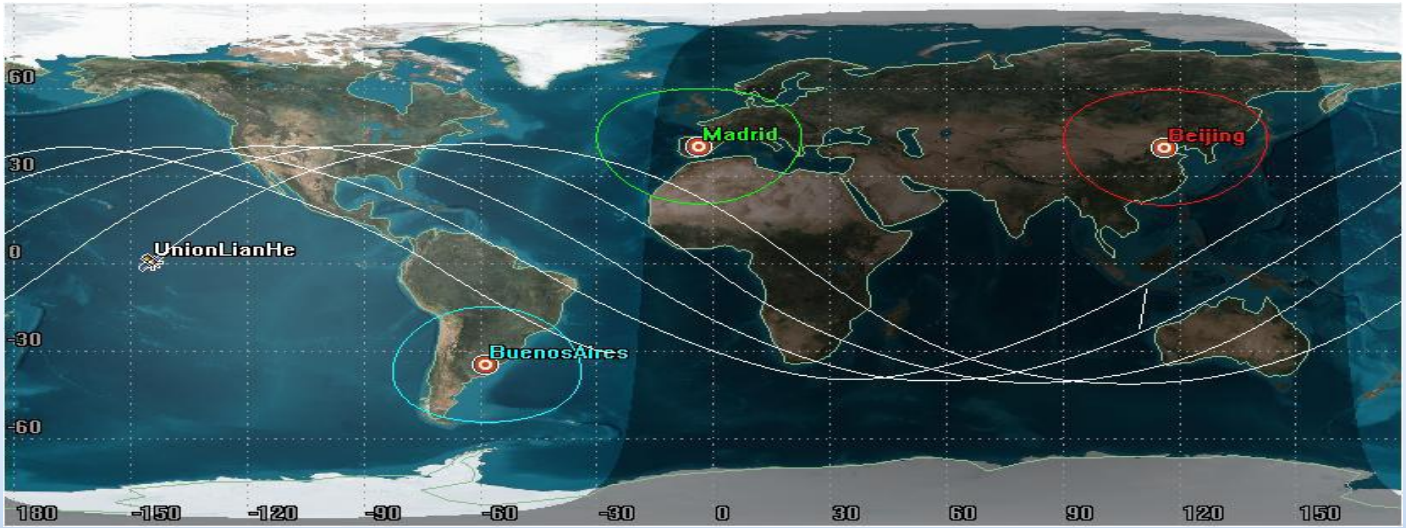
Example of a Case Study by MUSE students using STK

Access – Segment Earth

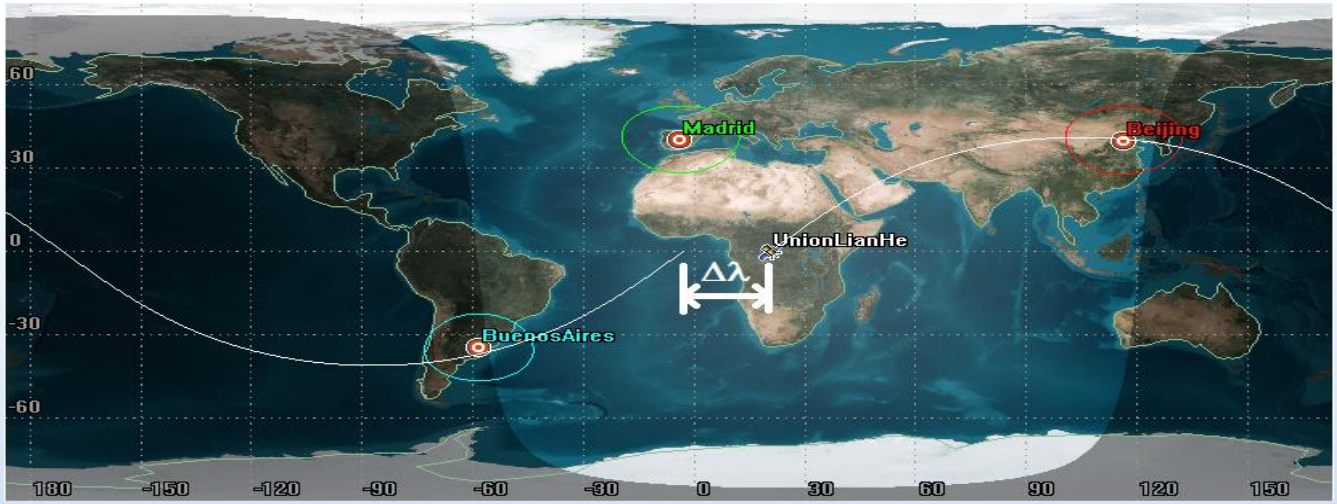


Accesses study

- **Two confirmed stations: Madrid and Beijing**

  One possible station: Buenos Aires
  - **Calculate accesses times**
  - **Determine accesses sequence and periodicity**
  - **Maximum and minimum time between accesses**
  - **Study how Buenos Aires station would increment the availability**

Nodal Precession



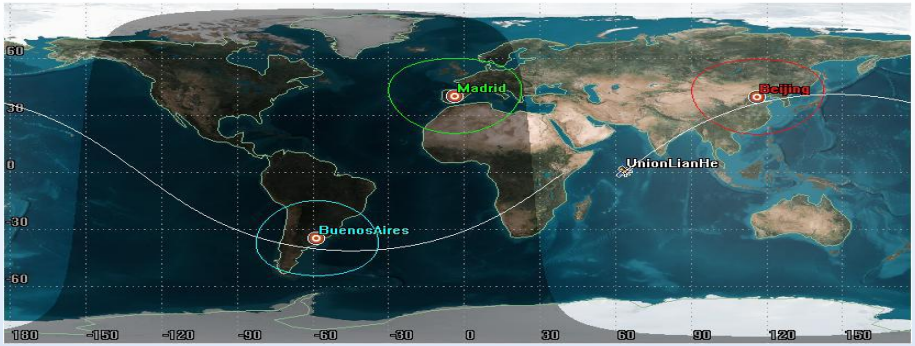
$\Delta\lambda = -23.55°$

Orbit study

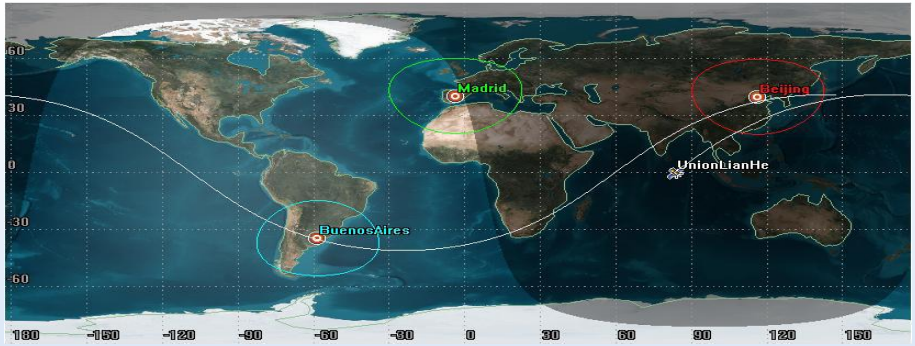
- **Orbit duration 1 h 32 min 23.434 s.**
- **15.59 orbits per day**
- **Nodal precession $\Delta\lambda = -23.55°$**
- **Repeatability:**

Period	Orbits	Error in repetition
2 d 22 h 49 min 57.985 s	46	-3º 21’
3 d 21 h 55 min 49.501 s	61	+3º 23’
6 d 20 h 45 min 47.485 s	107	+2’

Sequences of accesses

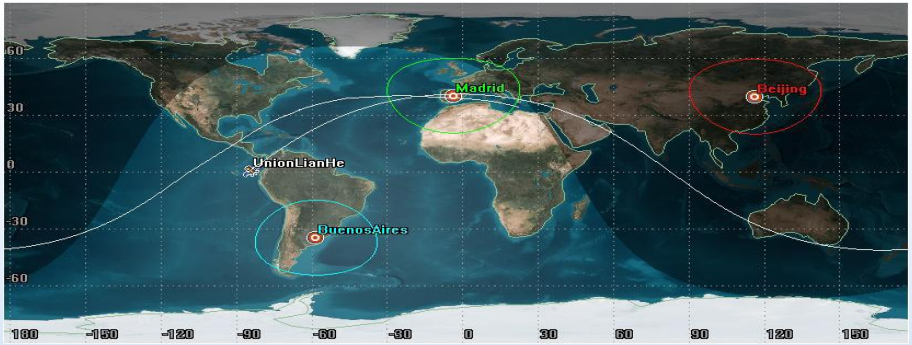


Example of orbit →

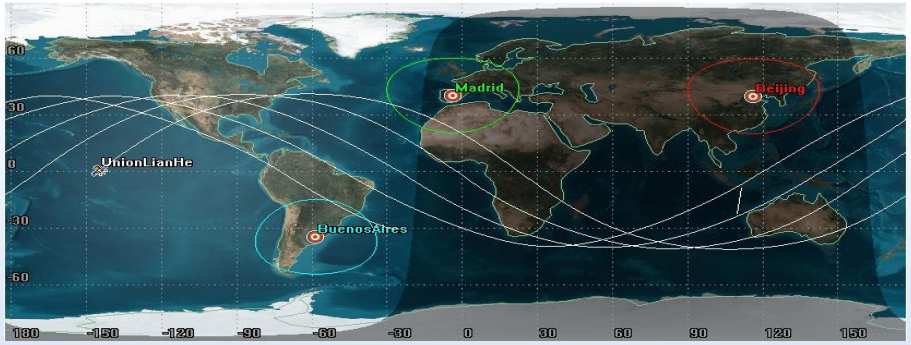


Example of orbit →

Sequences of accesses



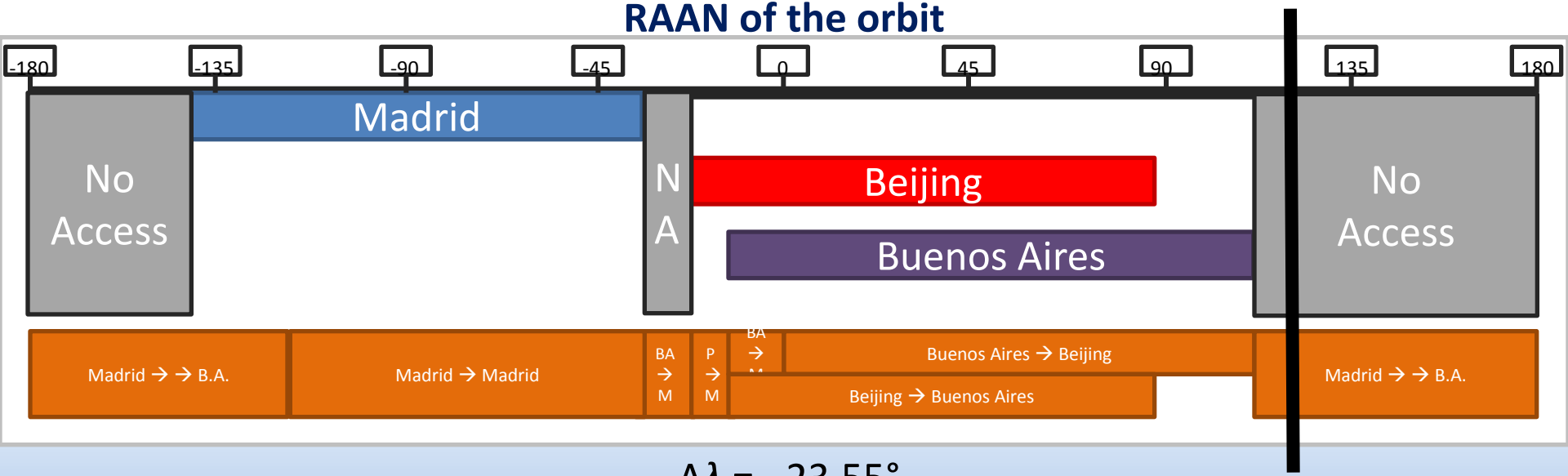
Example of orbit 🇪🇸 → 🇪🇸



Example of orbit 🇪🇸 → → 🇦🇷

Access Schedule

RAAN of the orbit



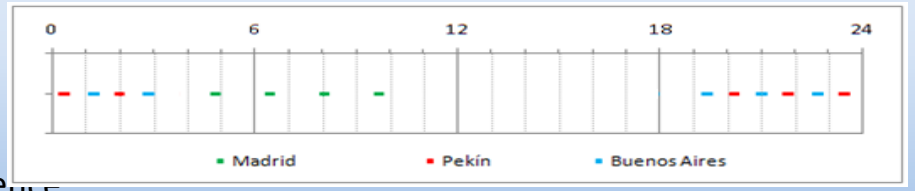
$$\Delta\lambda = -23.55°$$

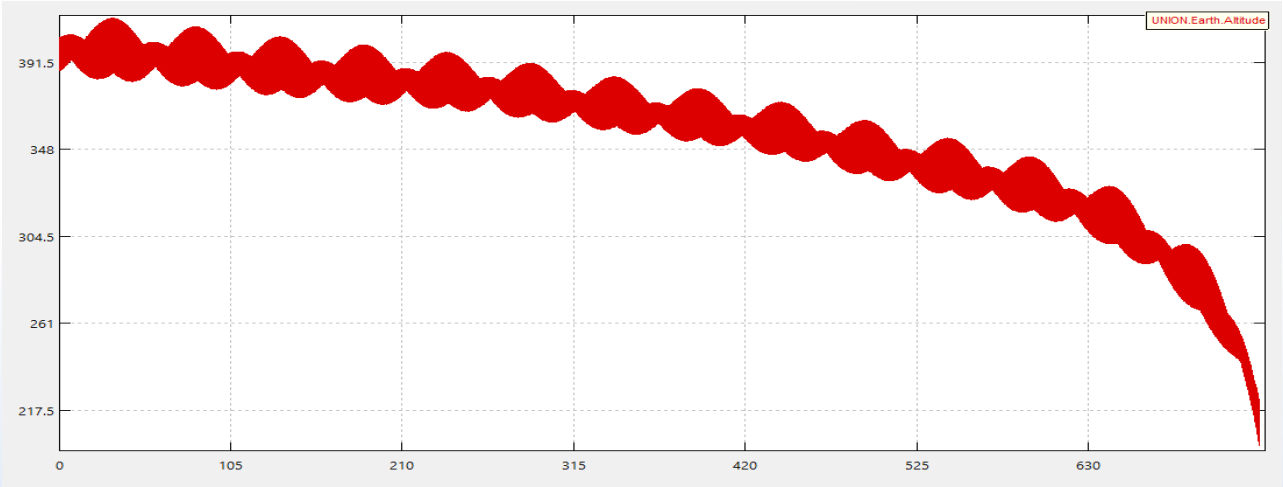
Some quick conclusions:

- Max access time 6 min 37 seconds
- Average access time 5 min 48 seconds
- Access time 13.7 hours per month
- Max time without access 9 h 38 min

113 < RAAN < -118º Madrid → Buenos Aires

5 or 6 complete orbits without access





Mission Lifetime

Lian-He mission lifetime study

- Initial orbit of the spacecraft is low, only 400 km
- Study of the lifetime is crucial

Lian-He mission characteristics

Parameter	Simbol	Value
Drag coefficient	C_D	2.2
Solar radiation coeficient	C_r	1
Frontal Area	A_f	0,25 m^2
Mass	M	50 kg
Solar flux sigma	σ	5 σ

Other missions study

– **Other missions have been studied as reference**

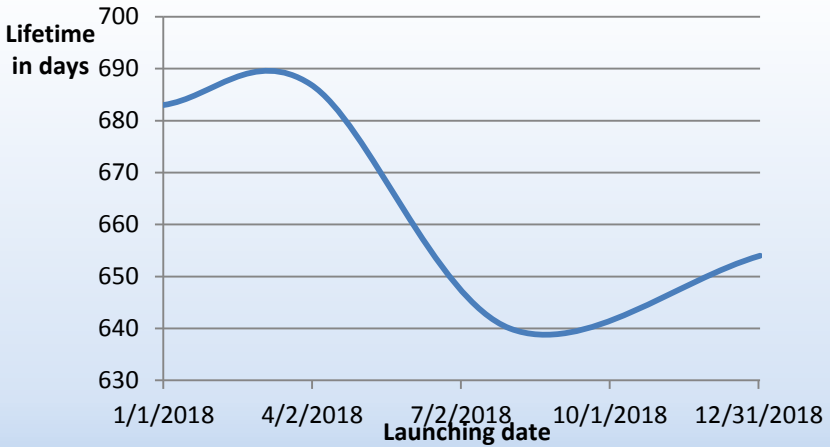
Mission	Real lifetime	Lifetime prediction Solar Flux CCSI	Lifetime prediction Solar Flux Schatten
CUTE-1.7 + APD	1342	1131.5	766.5
Genesat 1	1327	1679	1533
Aerocube 3	597	520.5	584
Hayato	39	25	24
Waseda-sat2	53	22	21
Negai	37	18	18

– **Jacchia 1970 Lt with Schatten models will be used because they produce conservative results**

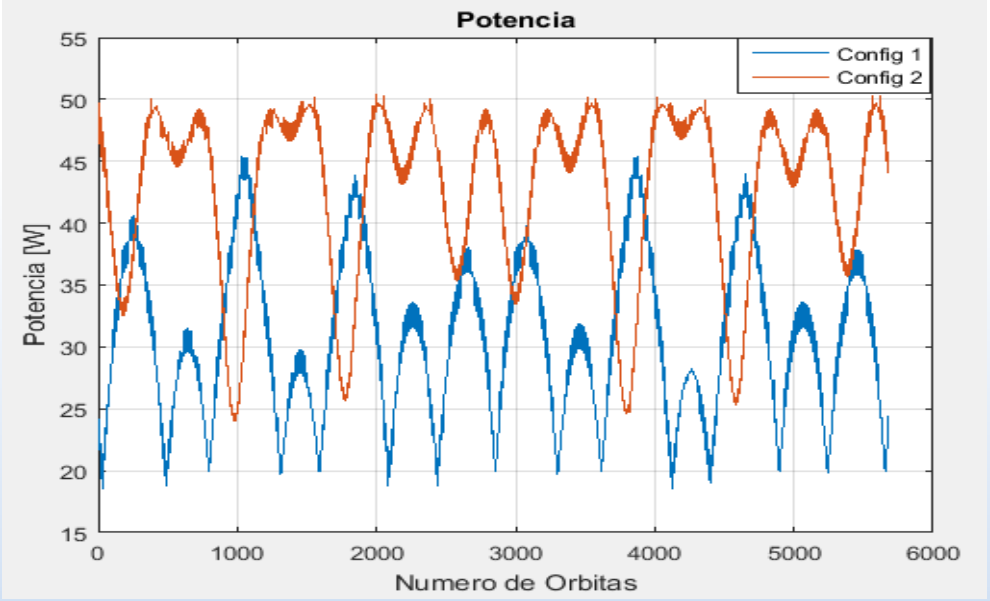
Lian-He mission lifetime study

Lian-He mission lifetime

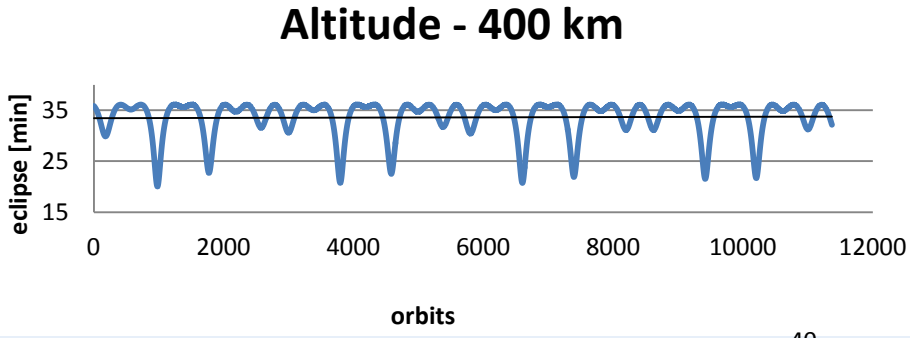
Launch date	Lifetime in days	Lifetime in years
2018 – 01 – 01	683	2.30
2018 – 04 – 01	687	2.46
2018 – 08 – 01	640	2.41
2019 – 01 – 01	654	2.45



Eclipses and power produced by the panels

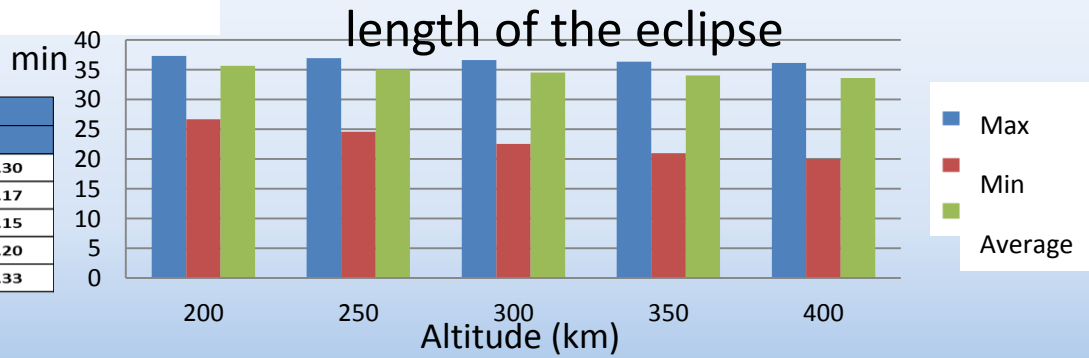


Eclipses:

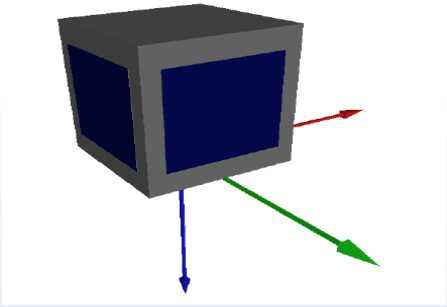


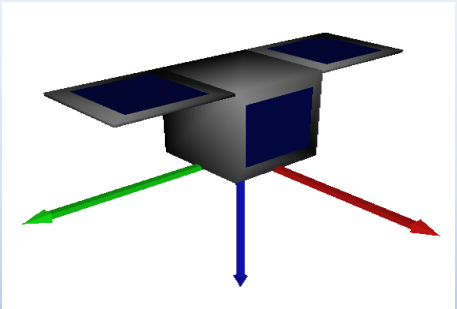
– Necessary for battery sizign
– Previous to power study

Lengh of the Eclipse				
Altitude (km)	Max (min)	Mix (min)	Average (min)	%
200	37.28	26.67	35.64	40.30
250	36.91	24.58	35.04	39.17
300	36.61	22.54	34.51	38.15
350	36.36	21.00	34.03	37.20
400	36.14	20.03	33.61	36.33



Solar Power:

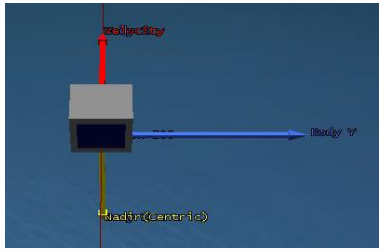


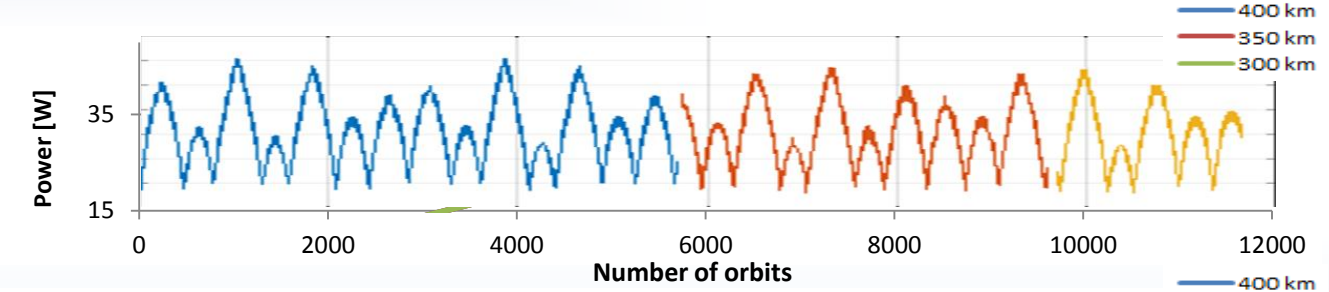


- Solar panels in the laterals of the satellite
- Two configurations of panels
- Z axis pointing to Nadir
- Analysis of the free axis 0º, 22.5º and 45º
- Three altitudes
- Effective area of the faces 60%
- Panel efficiency of 28%

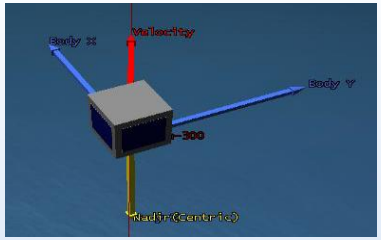
$$P = \eta \cdot I \cdot A_{ef} \cdot E$$

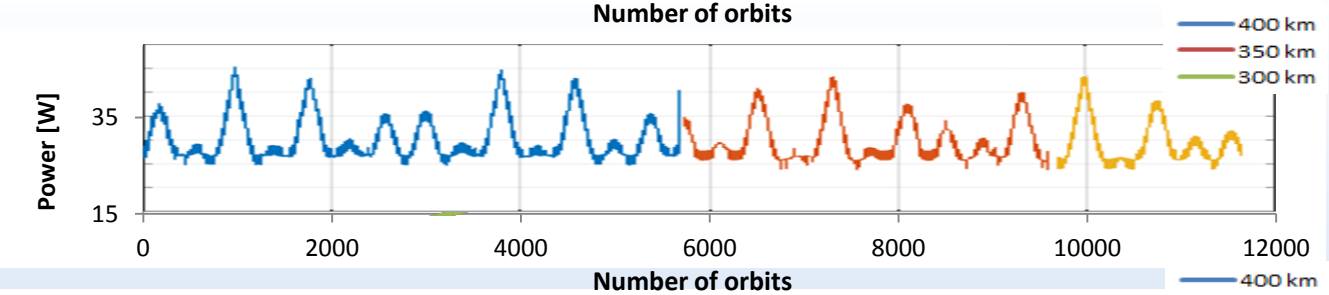
0º


Velocity
Body Y
Nadir (Generic)


400 km
350 km
300 km
Power [W]
35
15
0
2000
4000
6000
8000
10000
12000
Number of orbits

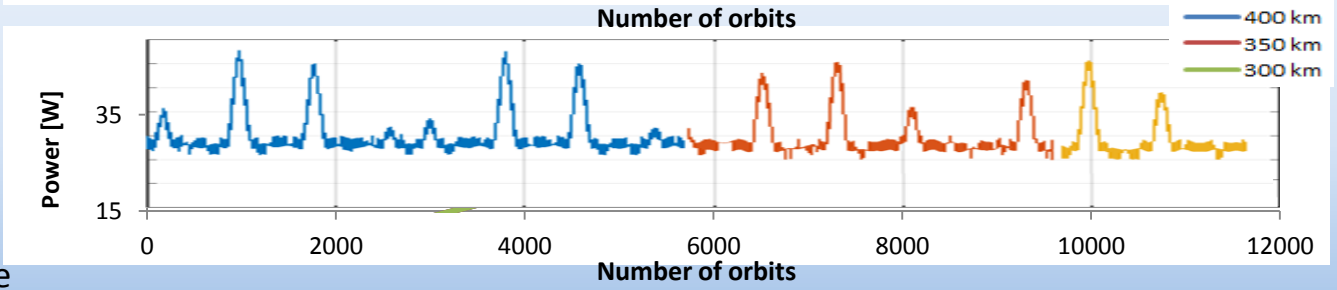
22.5º

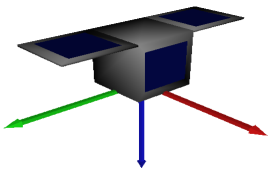

Body X
Velocity
Body Y
300
Nadir (Generic)

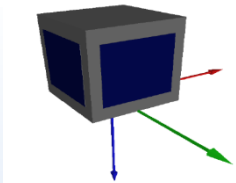

400 km
350 km
300 km
Power [W]
35
15
0
2000
4000
6000
8000
10000
12000
Number of orbits

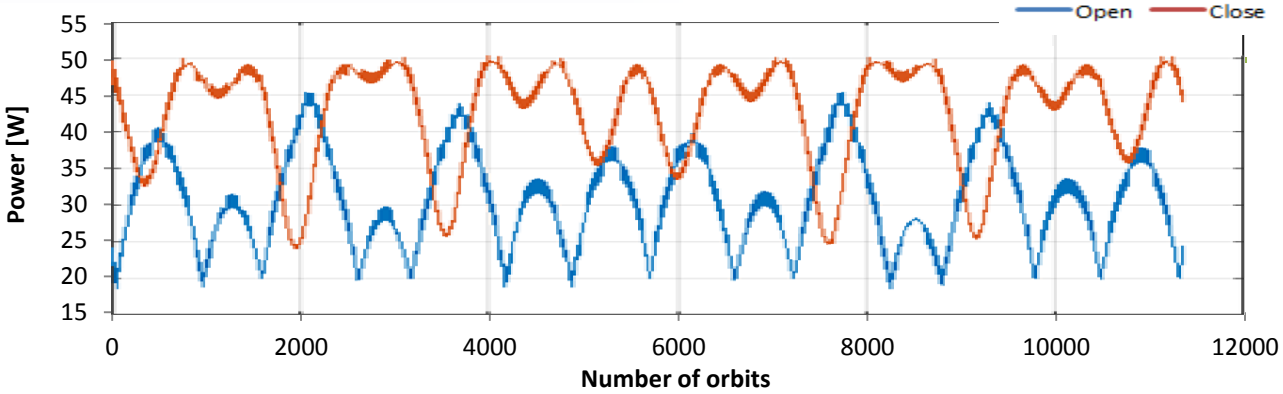
45º


Velocity
Body X
Body Y
300
Nadir (Generic)


400 km
350 km
300 km
Power [W]
35
15
0
2000
4000
6000
8000
10000
12000
Number of orbits







Summary

Orientation	Averaged Power [W]	Max. power [W]	Min. power [W]	Peak of power [W]
Closed 0º	30.39	45.37	17.99	65.93
Closed 22.5º	29.83	48.26	20.80	70.49
Closed 45º	29.67	47.67	22.21	67.30
Open	42.68	50.37	24.03	103.63

Future cases of study?

- Coverage analysis
- Evaluate Communications Links
- Launch
- Precise attitude and orbit propagation
- …

More information

- **MUSE: http://muse.idr.upm.es/**
- **IDR: http://www.idr.upm.es/**

Bibliography

- Pindado Carrion, S., et al. (2016). MUSE (Master in Space Systems), an advanced master's degree in space engineering. Athens: ATINER'S Conference Paper Series, No: ENGEDU2016-1953.
- B. Torres, A. Rodríguez, A. G. Maldonado, N Fernandez de Bobadilla. Orbit study and analysis of the Lian He - Union mission.

Thank you